TECHNICAL REPORT

ITEM #0001AA

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DEVELOPMENT OF INJURY PREVENTING HELMET SERVO-SUPPORT SYSTEM FOR HIGH PERFORMANCE AIRCRAFT

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Section I. Purpose and Scope of the Research Effort

The technical objective of this program is the development of a support system for the aviator's helmet wherein the load created by the helmet and helmet mounted equipment is removed from the aviator's head and is transferred directly to the aviator's seat and airframe. The support system, while supporting the helmet load, shall be powered and controlled to move with the aviator's head such that the helmet is retained on the aviator's head in a normal manner. The support system shall provide freedom of head movement and allow the aviator to easily control the movement of his/her head, his/her helmet and the helmet mounted equipment.

The technical objective of this program is being undertaken in the form of a multi-task program as outlined in the proposal. The objectives of the individual tasks are presented below.

1. Definition of System Parameters.

The objective of this task is to identify and establish values and/or limits for all system parameters that must be satisfied in the embodiment of the support system or that serve as factors in the development of a more reliable or optimal system. This specific information is required to ensure that project effort is properly directed toward the development of a system that will meet the overall technical objective of the program.

2. Select Optimal System Characteristics.

The objective of this task is to optimize the kinematics, control strategy, and energy requirements for the helmet support system. To facilitate this effort, a comprehensive computer simulation of the dynamic interaction between the helmet support hardware and the aviator will be developed.

3. Complete Mechanical System Layout Including Drive and Mechanical Component Selection.

The objective of this task is to complete the selection of all mechanical components, provide the specifications for the selected components and provide design layouts establishing the proper assembly, clearances, fit and functions of all components within the proposed design. Utilizing the system parameters as defined in Task 1 and the design optimization results determined in Task 2, this task serves as the means to establish component and design details in light of

specific requirements and to select components that thereby optimize the design of the mechanical system.

4. Complete the Electrical Control System Layout Including Component Selection and Determination of System Characteristics.

The objective of this task is to complete the design of the helmet support control system to satisfy the performance requirements identified in Task 1. To facilitate this effort, the proposed control system will be optimized through an iterative analysis with a modified head-spine mathematical model (HSM).

The foregoing provides for the development of the helmet servo-support system for high performance aircraft in accordance with the proposed effort.

Section II. Overall Progress To Date

The identification of the design parameters for the helmet support system and the determination of practical limits or values for these parameters is the primary focus of the initial project effort. A literature search intended to establish the most appropriate design specifications is near completion. The references used in the review are selected and reviewed for data that is specific to the pilot head loading, high "G" maneuvering, neck strain, and the anthropometric factors that need to be considered in the design. The selection of an optimal linkage arrangement and the overall development of the design is dependent upon obtaining adequate data on the helmet weight, head weight, rotational acceleration rates, rotational speeds, and translational acceleration levels. The C.G. location of various helmets and helmet mounted equipment is also under review.

System parameters selected to date are as follows:

1. Under flight conditions with translational accelerations less than 3g, the helmet servo-support system shall support the helmet and helmet equipment weight such that the loading between the head and helmet is reduced to less than 4.6 kg force and 11.5 kg-cm or less of force moment. The intent here is to support most of the helmet and helmet equipment weight but not the pilots head. The pilot controls the helmet position by applying a force or moment in the direction of the desired travel. Force moments and force levels at the occipital condyles are used as an indication of neck strain.

2. Under flight conditions with translational accelerations greater than 3g and less than 9g, the helmet servo-support system shall support all of the helmet and

helmet equipment weight along with approximately 50 percent of the pilots head inertia. Under this condition, the maximum sustained force moment of the helmet and helmet equipment on the pilots head shall not exceed 34.5 kg-cm. The intent here is to support the helmet and helmet equipment, to support any excess moment resulting from the helmet or helmet equipment and to assist the pilot in counteracting his/her head inertia forces. The pilot controls the helmet position by counteracting more or less than the remaining inertia forces of his/her head.

3. The helmet support system will be designed to support the helmet and helmet mounted equipment during high accelerations situations such as landing and take-off and during ejection in which accelerations may be too high for the pilot to control his/her head. It is intended that the support system will lock the helmet into an appropriate position, such as a full head back position during these intervals. The servo-support will be sized to provide full support up to 27g in the direction of ejection and 20g in the remaining directions. Insufficient data is available at this time to further define control requirements during ejection.

4. The pilots head has a limited range of motion and to avoid the possibility of injury due to forced movement of the head beyond voluntary limits of motion, motion constraints are placed on the support system. Maximum lateral travel for the helmet support is established at 12 cm. in either direction from the center position . Maximum forward travel is established at 24 cm. from a complete headback position. Maximum vertical travel is established at 5 cm. from an adjustable neutral position. Allowable yaw rotation is 60 degrees in either direction from a center position. Allowable lateral flexion is established at 30 degrees in either direction from the center position. Allowable dorsiflexion is 45 degrees and allowable ventriflexion is established at 30 degrees.

5. Force levels between the head and helmet will be managed by the control system within the motion limits of the support system. Force constraints and displacement constraints will be introduced into the support system by the control system to mitigate any problem with forced motion within the motion limits of the support system. Force levels will be managed in general accordance with items #1, #2, and #3 above.

6. Maximum rotational pitch acceleration of the aircraft is established at 6 rad/sec^2. Maximum rotational roll acceleration of the aircraft is established at 6 rad/sec^2. Values for rotational acceleration in yaw were not found and are expected to be not significant.

7. Range of lateral motion of the upper torso of the pilot within the shoulder harness of the aircraft seat is established at a maximum of 12 cm. in either lateral direction from the center position. Range of vertical motion of the upper torso at the base of the neck is established at 5 cm. in either direction from an adjustable

neutral position. The range of forward motion of the upper torso from a full back position is established at 12 cm.

8. Maximum head weight is established at 5.257 kg. Minimum head weight is established at 3.676 kg. The principal moments of head inertia range from 155.8 to 260.0 kg-cm^2 for head roll, 174.3 to 310.0 kg-cm^2 for pitch and 122.5 to 191.6 kg-cm^2 for yaw rotation.

9. Maximum helmet and helmet equipment weight is established at 2.7 kg. Information on the c.g. and the moment of inertia of the helmets and helmet mounted equipment is not available at this time. This information has been requested.

The primary emphasize of the present effort on this project is to define the system parameters as outlined in task 1 of the proposal. In addition, project activity has been initiated on tasks 2,3 and 4 of the proposal.

As shown in Table 1, the project is on schedule.

Section III. Problem Areas

1. Current Problems: The data obtained from available literature does not provide all of the specific information desired for the definition of system parameters. Effort is underway to collect additional support data.

2. Anticipated Problems: None.

Section IV. Work to be Performed During the Next Reporting Period.

1. Continue to search for data where needed or where data would serve to better define the system parameters.

2. Continue the effort to develop and optimize the mechanical and electrical systems for the helmet support in accordance with the proposal.

Section V. Administrative Comments

A visit to NAWC for review of available anthropometric data on aviators and for review of data on helmets and helmet mounted equipment is scheduled for November 1, 1994.

DEVELOPMENT OF HELMET SUPPORT SYSTEM

Task No.	Description	Week No.-> 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1	Definition of System Parameters	S						F																			
2	Simulation to Select Optimal Arrangement	S										F															
3	Mechanical Support System Design				S																		F				
4	Electrical Control System Design				S																		F				
5	Preparation of Technical Drawings/Report																				S						F

Table 1. PROJECT SCHEDULE